Rodents and Their Involvement in Disease Transmission

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Tarrant County Public Health

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Overview

- Rodents
  - Why rodents?
  - Direct, indirect and zoonoses
- Rodent Related Diseases (direct)
  - Hantavirus
  - Leptospirosis
  - Lymphatic Chorio-meningitis
  - Plague (both direct and indirect)
  - Rat Bite Fever
  - Salmonellosis
  - Tularemia
- Rodent Related Diseases (indirect)
  - Babesisosis
  - Cutaneous Leishmaniasis
  - Human Granulocyctic Anaplasmosis
  - Lyme Disease
  - Murine Typhus
  - Relapsing Fever
  - Rocky Mountain Spotted Fever

Reportable Diseases/Notifiable Conditions

- Doctors MUST report these conditions
  - Within certain timeliness
    - Dependent on transmissibility
    - Dependent on potential of bioterrorism agent
    - Dependent on reemergence
- Must meet certain criteria to be “counted” as a case
  - Identifying main symptom
  - The presence of the agent must identified
    - Requires some kind of harvested fluids (usually blood)
    - PCR
    - IgM + (not IgG…)
    - Sometimes one method, like the detection of IgM can be complicated due to cross-reactivity of antibody detection

Section I

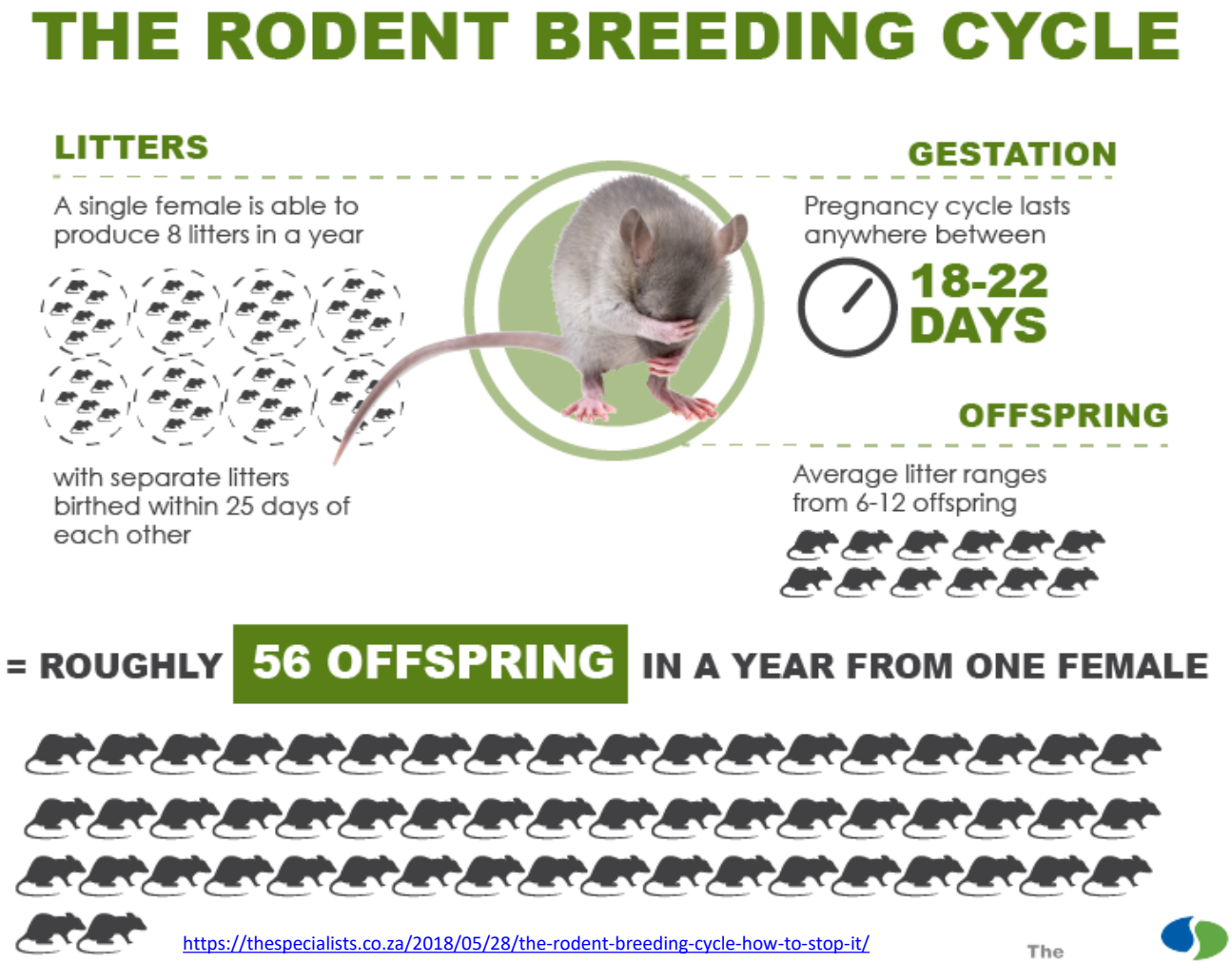
RODENTS AS VECTORS

Why Rodents?

- Diversity
- Abundance
- Cryptic
- Nocturnal
- Adaptability
- Parasites
- Peridomestic
- Transport

https://www.gettyimages.com/detail/photo/plague-of-rats-aboard-ship-1910-royalty-free-image/523642788?adppopup=true

Why Rodents?



https://thespecialists.co.za/2018/05/28/the-rodent-breeding-cycle-how-to-stop-it/

The Specialists
Pest Control · Cleaning · Hygiene

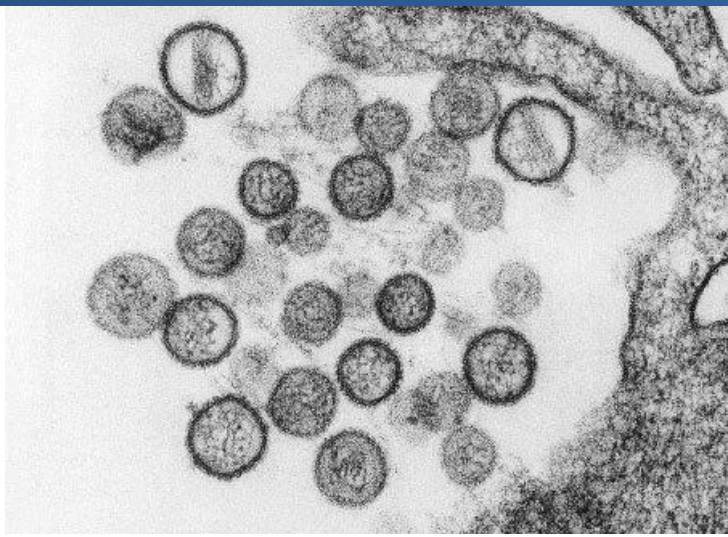
Direct or Indirect

- Vector- a living organism that may transmit infectious pathogens
- Direct
  - Droppings
  - Urine
  - Rodent bite or scratch
- Indirect
  - Involved in a cycle of a disease (zoonoses), but not as the vector

Section II

DIRECT RODENT ASSOCIATED DISEASES

Hantavirus Pulmonary Syndrome



https://www.medicinenet.com/hantavirus_pulmonary_syndrome/article.htm

- Agent
  - *Hantaviriidae: Orthohantavirus*
  - Sin Nombre virus and others
- Reservoir/Vector
  - Deer mouse (*Peromyscus maniculatus)*
  - White-footed mouse or wood mouse (*Peromyscus leucopus)*
  - Cotton Rat (*Sigmadon hispidus)*
  - Rice rat *(Oryzomys palustris)*
- Mode of Transmission
  - Contact with or consumption of urine, feces, or other fluids from a rodent

Hantavirus Pulmonary Syndrome

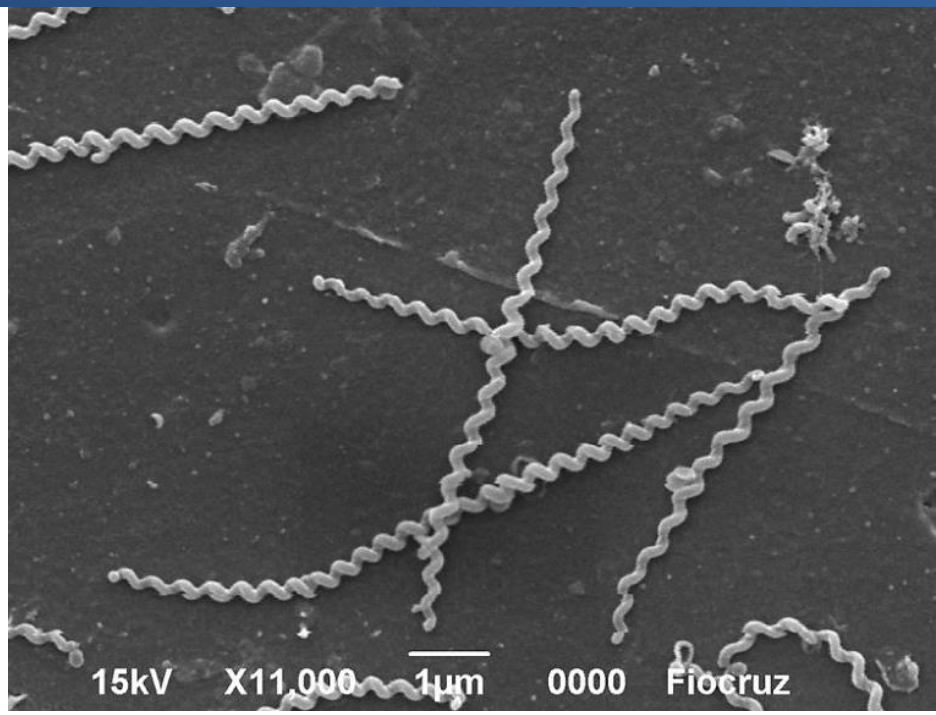
- Hemorrhagic Fever with Renal Syndrome (HFRS) – disease caused by Hantavirus that only occurs in Asia and Europe
- Incubation 1 – 8 weeks
- Symptoms (HPS)
  - Early symptoms for 3-5 days
    - Fatigue (universal)
    - Fever (universal)
    - Muscle aches (universal)
    - Headaches
    - Dizziness
    - Chills
    - Abdominal issues: vomiting, diarrhea, and abdominal pain
  - Late symptoms 5-7 days
    - Shortness of breath
    - Pulmonary edema
    - Cardiac failure
    - Shock
  - Last phase (diuretic phase)
    - Improvement of symptoms
    - Diuresis

Hantavirus Pulmonary Syndrome

- Recovery can take months
- Mortality is about 38%
- Treatment
  - Nothing specific
  - May need ventilator and oxygen

https://en.wikipedia.org/wiki/Ventilator

Leptospirosis



- Agent
  - *Leptospira*
  - Aerobic, right handed helical gram negative spirochete
- Reservoir/Vector
  - Cattle
  - Pigs
  - Horses
  - Dogs
  - Rodents
  - Wild animals
- Mode of Transmission
  - Contact with or consumption of urine, feces, or other fluids from the various reservoirs or exposure to contaminated soil/water/food

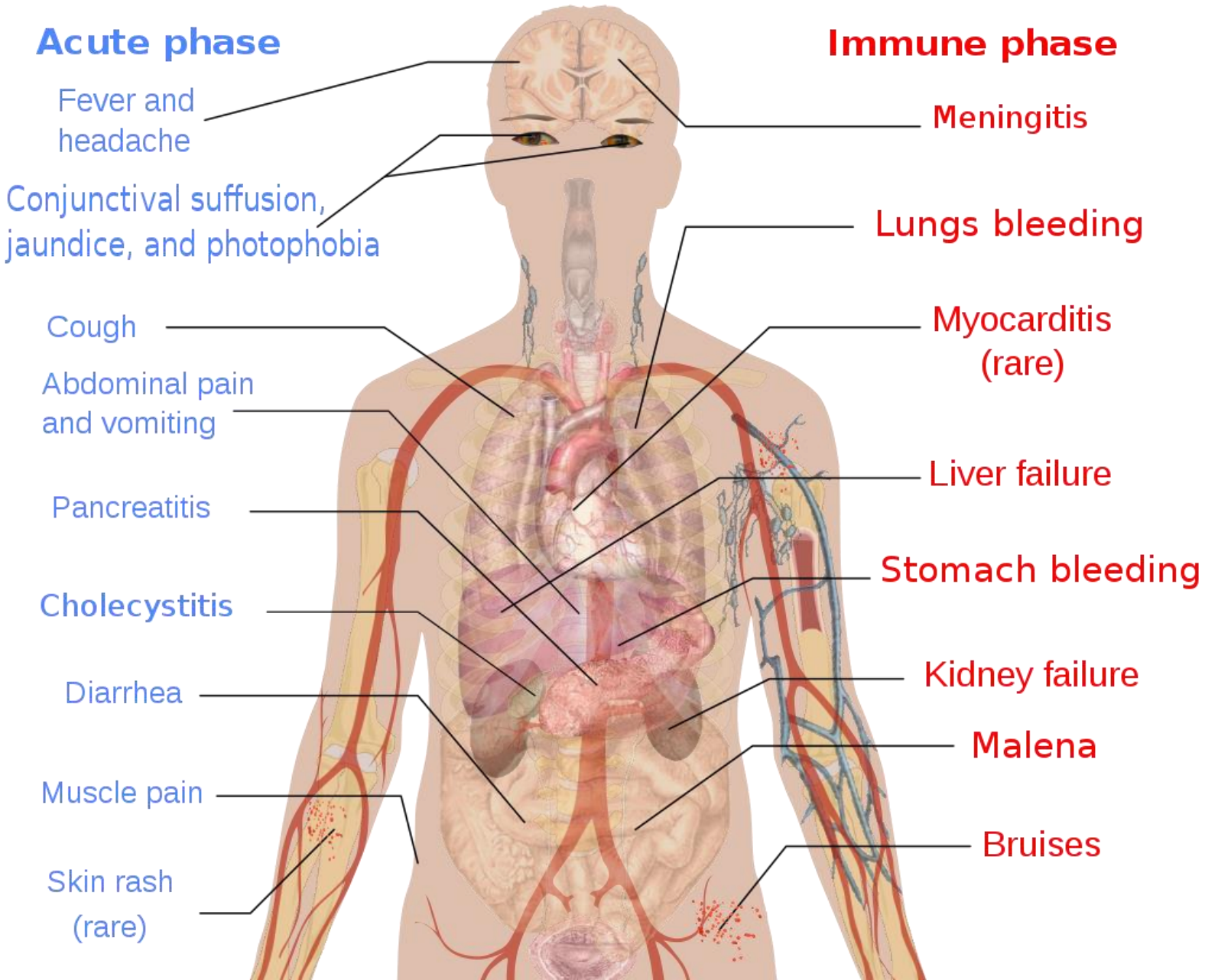
Leptospirosis

- May be acquired from natural body waters
- Can be a major problem when natural disasters happen such as flood and/or hurricanes
- Animals may also experience symptoms
- Incubation period
  - 2 days to 4 weeks
- Treatment
  - Doxycycline

https://www.cdc.gov/leptospirosis/features/outdoor-activities.html

Symptoms and signs of

Leptospirosis

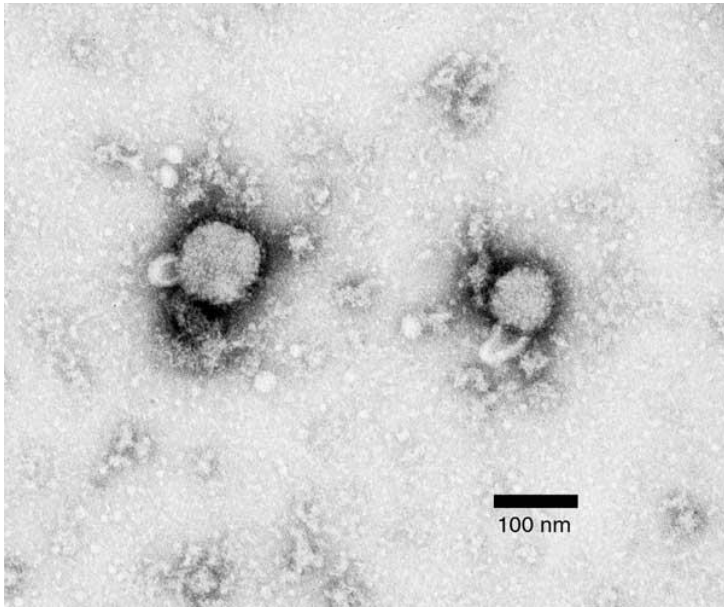


Lymphatic Choriomeningitis

- Agent
  - *Arenaviridae:* Lymphocytic chriomeningitis mammarenavirus
  - Aerobic, right handed helical

  gram negative spirochete
- Reservoir/Vector
  - House mouse (*Mus musculus)*
  - Other domestic rodents (hamster, rat, guinea pig)
- Mode of Transmission
  - Contact with or consumption of urine, feces, or other fluids from the various reservoirs or exposure to contaminated soil/water/food

https://en.wikipedia.org/wiki/Lymphocytic_choriomeningitis



https://commons.wikimedia.org/wiki/File:%D0%9C%D1%8B%D1%88%D1%8C_2.jpg

Lymphatic Choriomeningitis

- Incidence is low due to under-reporting
- Incubation period
  - 8 to 13 days
- Symptoms
  - Initial phase (~ 1 week)
    - Fever
    - Malaise
    - Lack of appetite
    - Muscle aches
    - Headache
    - Nausea
    - Vomiting
  - Phase two (neuro)
    - Meningitis
    - Encephalitis
    - Acute hydrocephalus
    - Myelitis

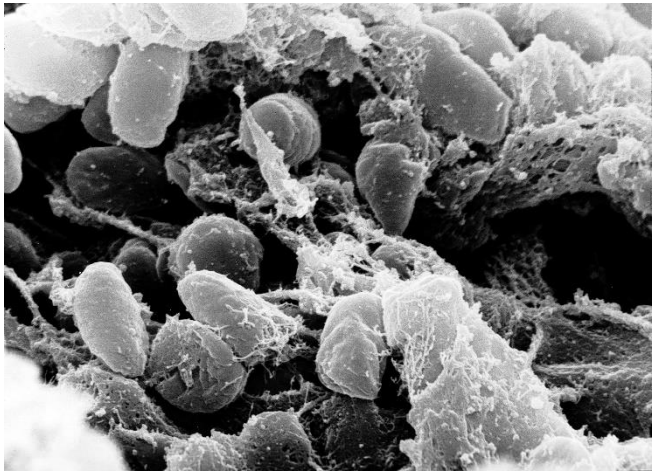
https://kauveryhospital.com/blog/neurology/doctor-i-have-heard-about-the-harmful-impact-of-meningitis-could-you-give-me-a-clear-picture-of-this-illness/

https://www.researchgate.net/figure/Hydrocephalus-with-increased-head-circumference-in-a-3-month-old-child_fig4_234071019

Lymphatic Choriomeningitis

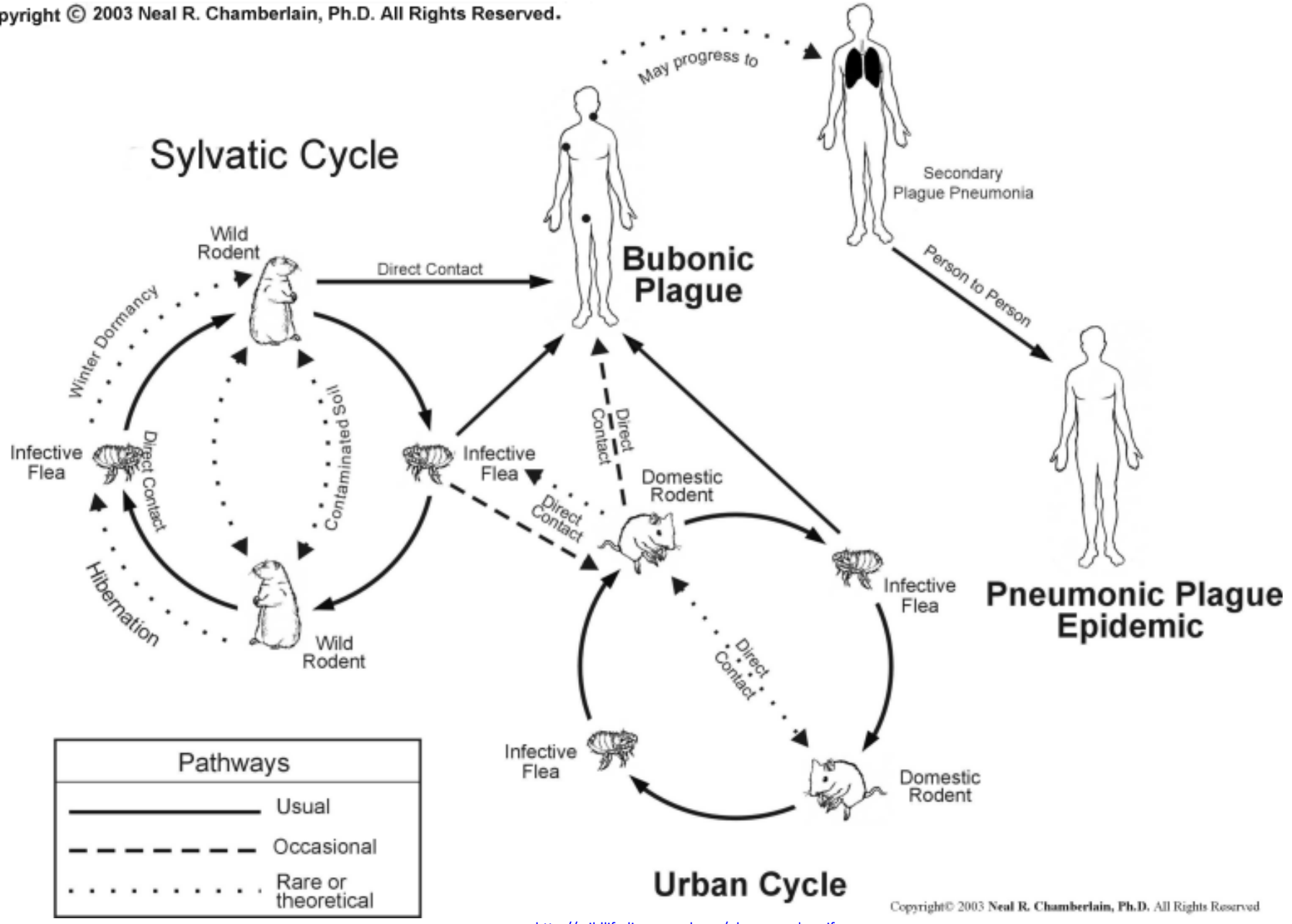
- May include congenital infections resulting in:
  - Deafness
  - Blindness (chorioretinitis)
  - Mental retardation
  - Hydrocephalus (water on the brain)
  - Spastic quadriparesis
  - Seizures
  - Macrocephaly
  - Microcephaly
  - Death
- Treatment
  - Anti-inflammatory medications
  - Nothing for babies born with congenital deformities

Plague AKA the Black Death



https://en.wikipedia.org/wiki/Yersinia_pestis

- Agent
  - *Yersinia pestis*
- Reservoir
  - Roof rat (*Rattus rattus)*
  - Norway Rat (*Rattus norvegicus)*
  - Other ground dwelling rodents
- Vector
  - *Xenopsylla cheopis, Oropsylla montana* and *Pulex irritans* (maybe all fleas, but only in certain conditions)
- Mode of transmission
  - Direct from flea, handling infected animals (septicemic/bubonic), direct contact from an infected person from infected surfaces (like soil) or through aerosolized droplets (pneumonic)
- Incubation period
  - 1 to 7 days, unless it is pneumonic, then 1 to 4
  - If a person has had plague and therefore has immunity, if symptoms occur, it may take longer than 7 days



http://wildlifedisease.unbc.ca/plague_cycles.gif

Plague Symptoms

- Chills, malaise, headaches, fever, vomiting blood, necrosis of extremities (black death)

Bubonic plague

Septicemic plague

Pneumonic plague

Three types = different symptoms

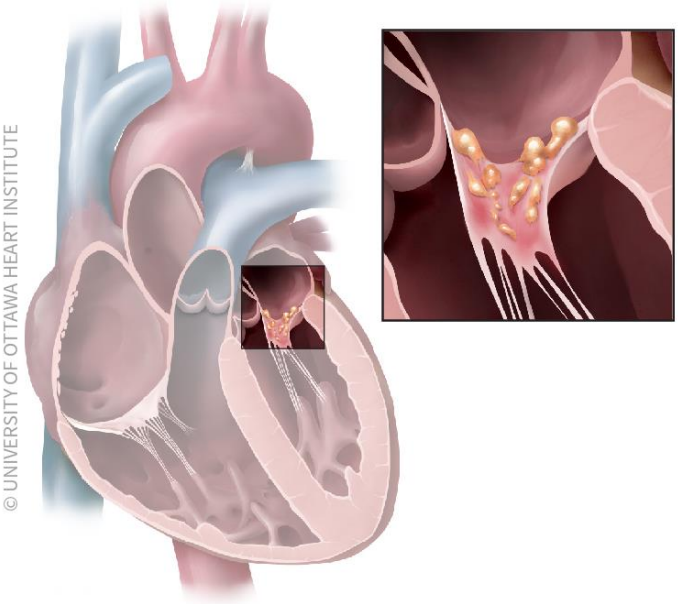
- Bubonic- swollen “buboes” or lymph nodes
- Septicemic- from draining buboes
- Pneumonic- respiratory form
- Treatment
  - Tetracycline group, Streptomycin, Chloramphenicol, Doxycycline, Gentamicin

Rat Bite Fever

- Agent
  - *Streptobacillus moniliformis*
  - Non-motile, gram negative, rod, microaerophile
  - “small rod necklace”
- Reservoirs
  - Norway rat (*Rattus norvegicus*)
  - Roof Rat (*Rattus rattus)*
  - Other domestic rodents (sometimes lab mice, guinea pigs, gerbils and squirrels)
- Mode of transmission
  - From the bite or scratch or from secretions from the host. Other animals may acquire infection from eating infected rodents, but this isn’t well understood
  - May also be transmitted through food and drink contaminated with rat urine of feces (known as Haverhill fever) (MS)
- Incubation period
  - 3 to 10 days

Rat Bite Fever

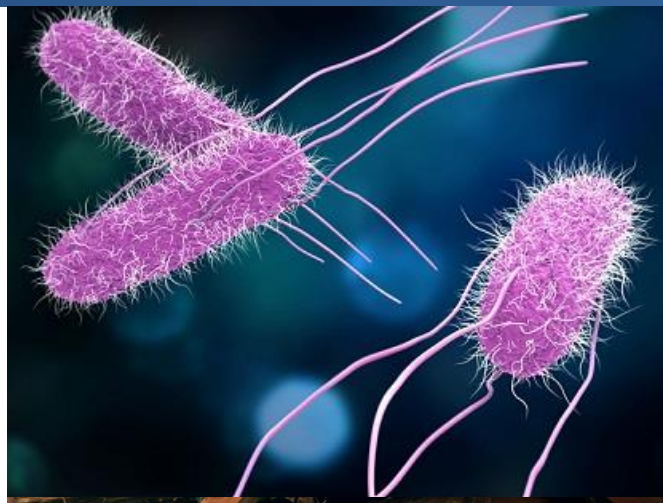
- Symptoms
  - Fever
  - Cold-like symptoms
  - Nausea
  - Headache
  - Vomiting
  - Muscle pain
  - Severe migratory joint pain
  - Rash on hands and feet
  - Sometimes endocarditis (inflammation of the inner lining of the heart)
  - 10% mortality
- Treatment
  - Amoxicillin, penicillin, erythromycin, doxycycline



https://www.ottawaheart.ca/heart-condition/endocarditis

Salmonellosis

- Agent
  - *Salmonella* spp
  - Gram-negative rod
- Reservoirs
  - Norway rat (*Rattus norvegicus*)
  - Roof rat (*Rattus ratus)*
  - Reptiles (including birds)
  - Most domestic animals, and even humans
- Mode of transmission
  - Fecal shedding from rodents
  - Exposure through handling animals
  - Kissing chickens
  - Eating undercooked contaminated mea

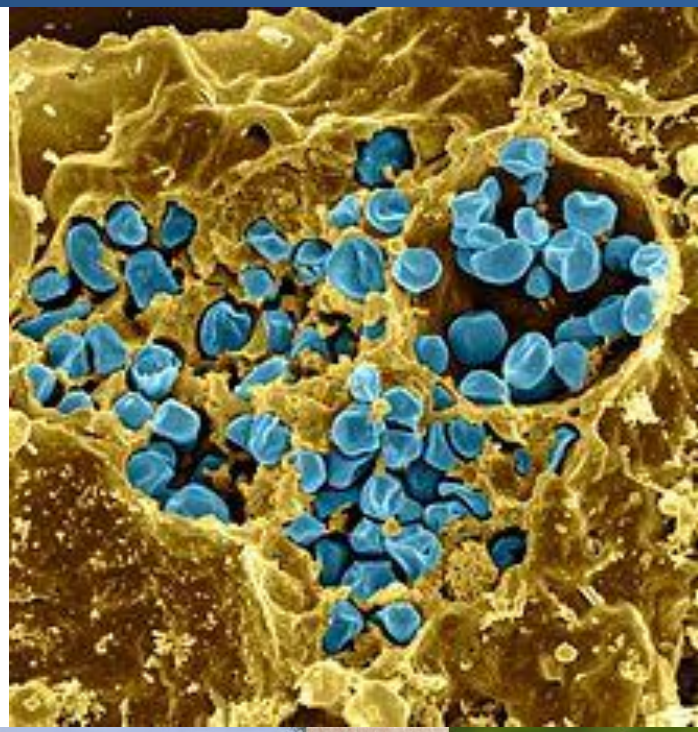


https://www.fda.gov/food/foodborne-pathogens/salmonella-salmonellosis
https://www.scarymommy.com/cdc-stop-kissing-pet-chickens/
https://www.healthyfood.com/ask-the-experts/raw-chicken/

Salmonellosis

- Outbreaks may be traced back to certain products (CDC has “current outbreaks” on their website)
- Incubation period
  - Usually 12 to 72 hours (6 hours to 6 days)
- Symptoms
  - Fever
  - Headache
  - Nausea
  - Stomach cramps
  - Diarrhea
  - Sometimes vomiting
- Treatment
  - Usually nothing, hydration recommended
  - Antibiotics for severe symptoms

https://en.wikipedia.org/wiki/Francisella_tularensis



Tularemia

- Agent
  - *Francisella tularensis*
  - Gram-negative aerobic coccobacillus
- Reservoirs
  - Lagomorphs
  - Rodents (voles, muskrats, beavers)
  - Some galliformes
  - Deer
- Vectors
  - Ixodidae (hard ticks- primary)
  - Mosquitoes (Scandinavia/Russia)
  - Some tabinidae (deer and horse flies)
- Mode of transmission
  - Direct contact with infected animals (aerosols)
  - Through the bite of infected vectors (particularly ticks)
  - Consuming meat of undercooked infected animals
  - Drinking infected water
  - Inhaling particles of contaminated soils/hay/grains or rabbits caught in a lawnmower*

https://www.cdc.gov/tularemia/index.html

Tularemia

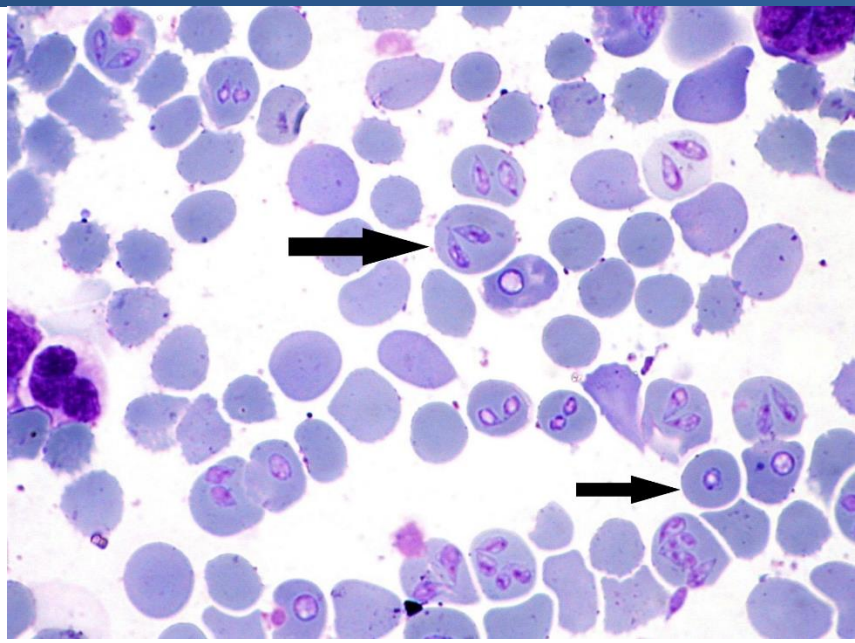
- Incubation period
  - Commonly 3 to 5 days, but can be 1 to 12 depending on inoculum
- Symptoms
  - Fever, headache, malaise, anorexia, myalgia, vomiting
  - Different forms
    - Ulceroglandular (tick/fly bite)
    - Glandular (without ulcer)
    - Oculoglandular (infection of eye)
    - Oropharyngeal (eating/drinking)
    - Pneumonic (inhaling)
    - Typhoidal (combonation)
- Treatments
  - Aminoglycosides
  - Tetracyclines
  - fluoroquinolones

https://www.nejm.org/doi/full/10.1056/nejmicm1801531

Section III

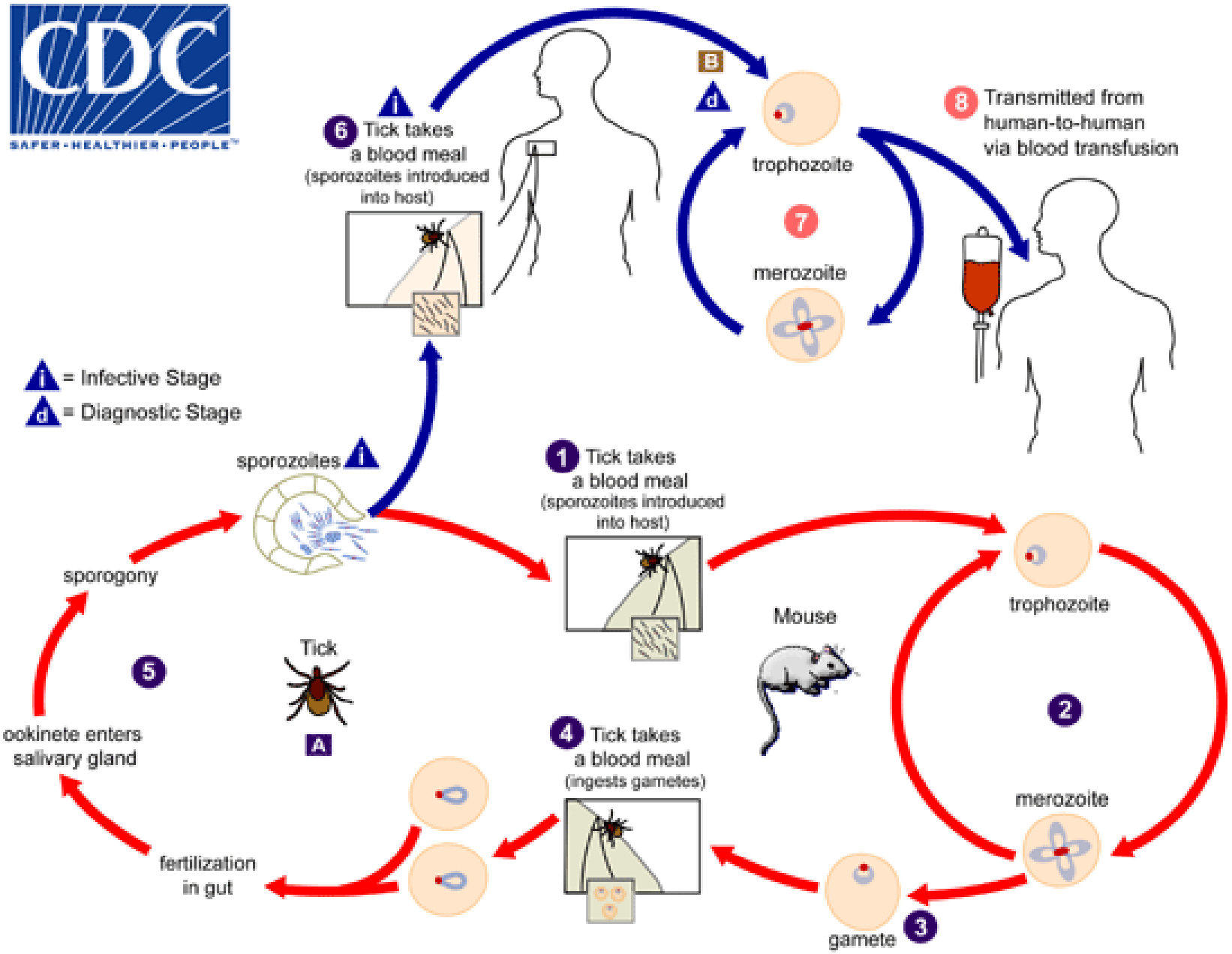
INDIRECT RODENT ASSOCIATED DISEASES

Babesiosis



https://en.wikipedia.org/wiki/Babesia_canis

- Agent
  - *Babesia* spp
  - Protozoans (like malaria)
- Reservoir/Vector
  - White-footed mouse (*Peromyscus leucopus*)
  - Other various small mammals
- Mode of Transmission
  - Through the bite of infected *Ixodes* tick (nymph)
  - Blood transfusions
  - Rarely congenital


CDC
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i = Infective Stage
d = Diagnostic Stage
1 Tick takes a blood meal (sporozoites introduced into host)
2
3
gamete
4 Tick takes a blood meal (ingests gametes)
5
6 Tick takes a blood meal (sporozoites introduced into host)
7
8 Transmitted from human-to-human via blood transfusion
A
B
Tick
Mouse
sporozoites
sporogony
ookinete enters salivary gland
fertilization in gut
merozoite
trophozoite
merozoite
trophozoite

Babesiosis

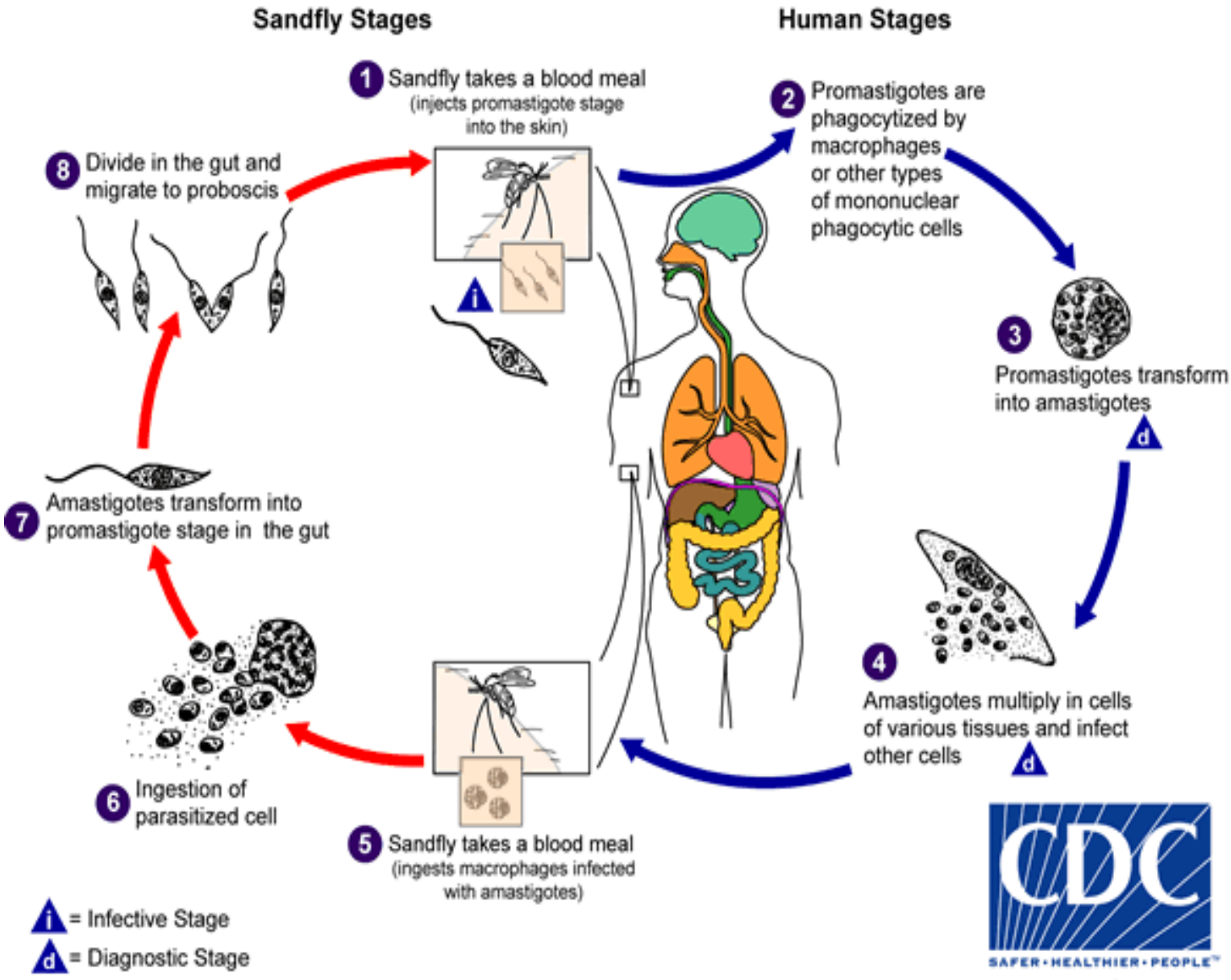
- Incubation period
  - 1 to 3 weeks, sometimes longer
- Symptoms
  - Many have no symptoms
  - Fever, chills, swears, headache, body aches, loss of appetite, nausea, fatigue
  - Complications may include:
    - Low and unstable blood pressure
    - Anemia
    - Low platelet count
    - Blood clots
    - Malfunction of vital organs
    - Death
- Treatments
  - Atovaquone + azithromycin
  - Quinine + clindamycin

Leishmaniasis

- Agent
  - *Leishmania* spp
  - Protozoan
- Reservoir
  - Wild rodents (gerbils)
  - Opossum
  - Hyrax
  - Dogs
  - Humans
  - Unknown
- Vector
  - *Lutzomyia* spp (sand fly) in the US
- Mode of Transmission
  - Through the bite of infected sand fly

https://www.quora.com/How-is-the-rock-hyrax-related-to-the-elephant

https://www.frontiersin.org/research-topics/8798/immunobiology-of-leishmaniasis


Sandfly Stages
Human Stages
1 Sandfly takes a blood meal
(injects promastigote stage into the skin)
2 Promastigotes are phagocytized by macrophages or other types of mononuclear phagocytic cells
3 Promastigotes transform into amastigotes
4 Amastigotes multiply in cells of various tissues and infect other cells
5 Sandfly takes a blood meal
(ingests macrophages infected with amastigotes)
6 Ingestion of parasitized cell
7 Amastigotes transform into promastigote stage in the gut
8 Divide in the gut and migrate to proboscis
i = Infective Stage
d = Diagnostic Stage
CDC
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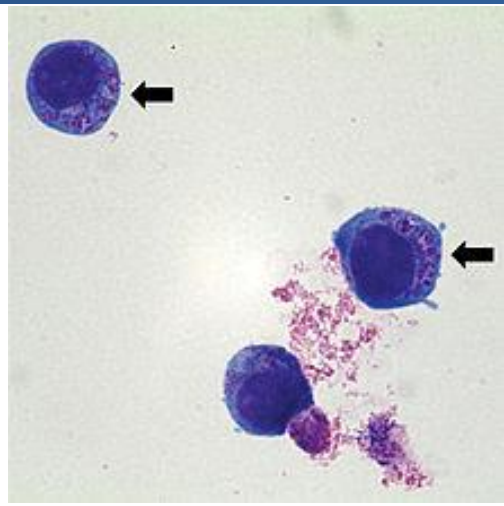
Leishmaniasis

https://www.cdc.gov/parasites/leishmaniasis/disease.html

- Incubation period
  - 1 week up to many months
- Symptoms
  - Cutaneous leishmaniasis (in US)
    - Ulcerative skin lesion
    - Starts as bumps or lumps
    - May have swollen glands
    - May be mucosal leishmaniasis
  - Visceral leishmaniasis (old world)
    - Fever, weight loss, enlarged spleen and liver, anemia, leukopenia, and thrombocytopenia
    - May be life threatening
- Treatments
  - Usually heals on it's own (ulcerative)
  - Visceral may be treated with miltefosine, amphotericin B deoxycholate, pentamidine and "azoles"

Human Granulocytic Anaplasmosis



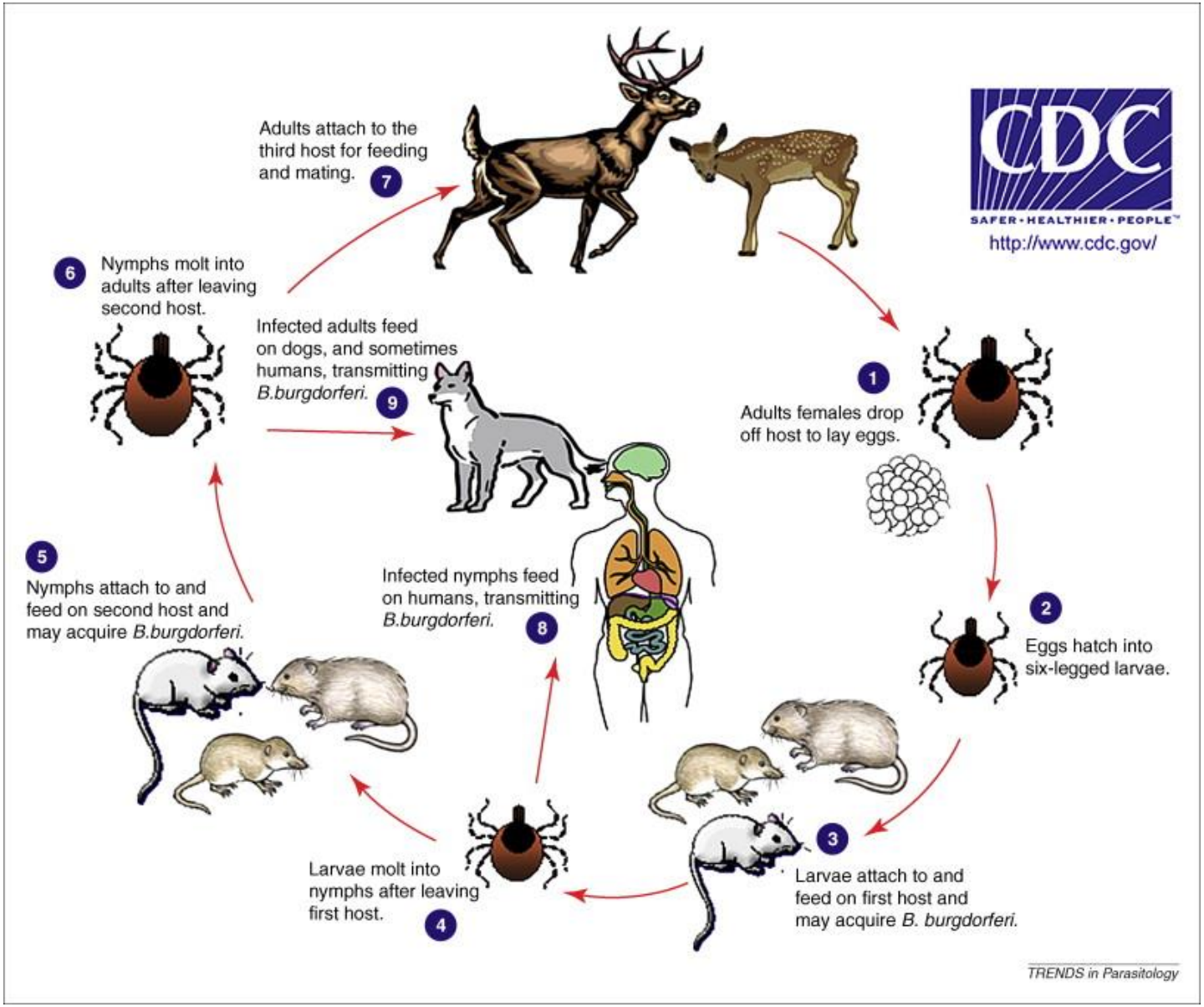
- AKA Anaplasmosis, tick-borne fever or pasture fever
- Agent
  - *Anaplasma phagocytophilum* formerly *Erlichia phagocytophilium*
  - Gram-negative obligate bacterium of neutrophils (WBC)
- Reservoir
  - White-footed mouse (*Peromyscus leucopusI)*
  - Many wild and domestic animals
- Vector
  - *Ixodes* spp (*scapularis* east and *pacificus* west)
- Mode of Transmission
  - Through the bite of infected *Ixodes* tick
  - Rarely through a blood transfusion

Human Granulocytic Anaplasmosis

- Incubation period
  - 7 to 14 days
- Symptoms
  - Fever with chills
  - Severe headache
  - Muscle aches
  - Nausea, vomiting, diarrhea, loss of appetite
  - Respiratory/organ failure
  - Bleeding issues
  - death
- Treatment
  - Doxycycline

Lyme disease

- Agent
  - *Borrelia burgdorferi*
  - Gram - mostly anaerobic spirochetes
- Reservoir
  - Wild rodents, especially the white-footed mouse
  - *Ixodes scapularis* and *Ixodes pacificus* (transtadial)
  - White-tailed deer (*Odocoileus virginianus*)
- Vector
  - *Ixodes scapularis* and *Ixodes pacificus*
- Mode of transmission
  - Through the bite of infected *Ixodes*

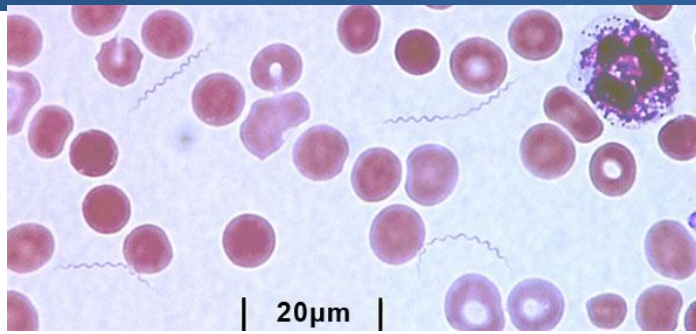

Adults attach to the third host for feeding and mating. 7
CDC
SAFER • HEALTHIER • PEOPLE™
http://www.cdc.gov/
6 Nymphs molt into adults after leaving second host.
Infected adults feed on dogs, and sometimes humans, transmitting B.burgdorferi. 9
1 Adults females drop off host to lay eggs.
5 Nymphs attach to and feed on second host and may acquire B.burgdorferi.
Infected nymphs feed on humans, transmitting B.burgdorferi. 8
2 Eggs hatch into six-legged larvae.
Larvae molt into nymphs after leaving first host. 4
3 Larvae attach to and feed on first host and may acquire B. burgdorferi.
TRENDS in Parasitology

Lyme disease

- Most common arthropod-borne disease reported in the USA
- Incubation period
  - 5 to 14 days
- Symptoms
  - Fever
  - Headache
  - Fatigue
  - Bulls-eye rash (Erthema migrans) -70 to 80%
  - Bell's palsy
  - Heart palpitations
- Treatment
  - Doxycycline

http://pixshark.com/borrelia-burgdorferi.htm

Relapsing Fever



- Agent
  - *Borrelia hermsii, B. parkeri,* and *B. turnicata*
  - Gram negative, mostly anaerobic spirochetes
- Reservoirs
  - Wild rodents (mostly chipmunks, tree squirrels and prairie dogs)
- Vector
  - Argasid ticks, namely *Ornithodoros hermsii,* but also *O. turnicata,* and *O. parkeri*
- Mode of transmission
  - From the bite of an infected soft tick
- Incubation period
  - 2 to 18 days, typically 7

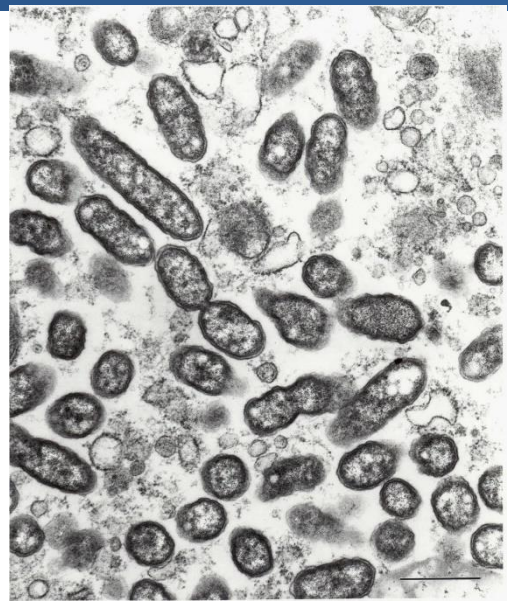
https://www.dshs.state.tx.us/IDCU/disease/TBRF/TBRF-Overview.aspx

Relapsing Fever

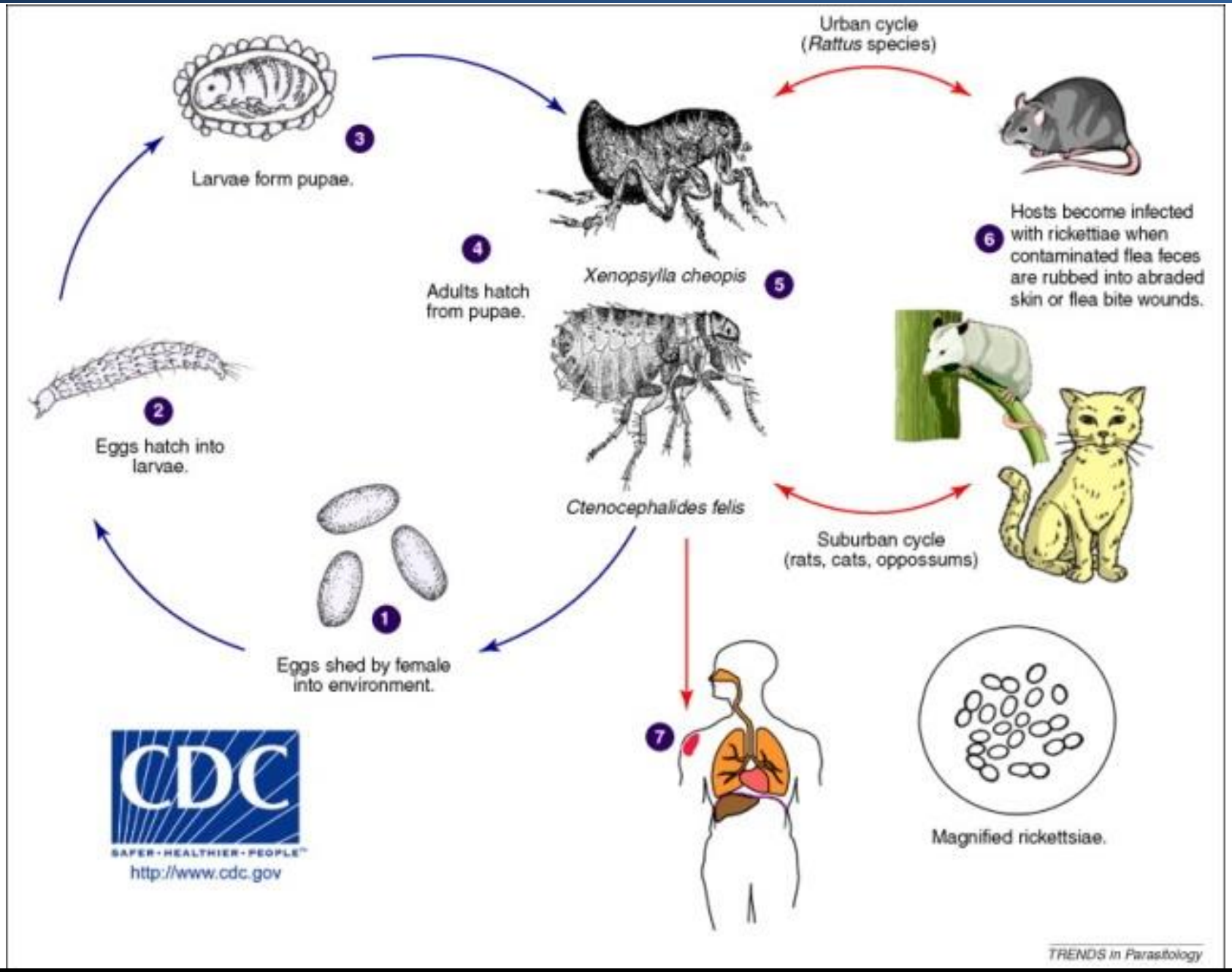
- In Texas, relapsing fever is commonly associated with caves (also Texas and west)
- Symptoms
  - High fever/chills
  - Headache
  - Muscle and joint aches
  - Nausea, vomiting, and abdominal pain
  - Occurring for 3 days, goes away for 7 and then reoccurring until treatment or clearing the agent
- Treatment
  - tetrcycline, doxycycline, and other antibiotic treatments

Murine Typhus/Spotted Fever

https://www.hgsc.bcm.edu/rickettsia-typhi



- Agent
  - *Rickettsia typhi; Rickettsia felis*
- Reservoir
  - Rodents particularly *Rattus rattus* and *R. norvegicus;* but also cats and opossum *(Rickettsia felis)*
- Vector
  - *Xenopsylla cheopis* and *Ctenocephalides felis*
- Mode of transmission
  - Through flea frass being scratched into wounds


Urban cycle
(Rattus species)
3
Larvae form pupae.
Xenopsylla cheopis
5
6
Hosts become infected with rickettiae when contaminated flea feces are rubbed into abraded skin or flea bite wounds.
4
Adults hatch from pupae.
2
Eggs hatch into larvae.
Ctenocephalides felis
Suburban cycle
(rats, cats, oppossums)
1
Eggs shed by female into environment.
7
CDC
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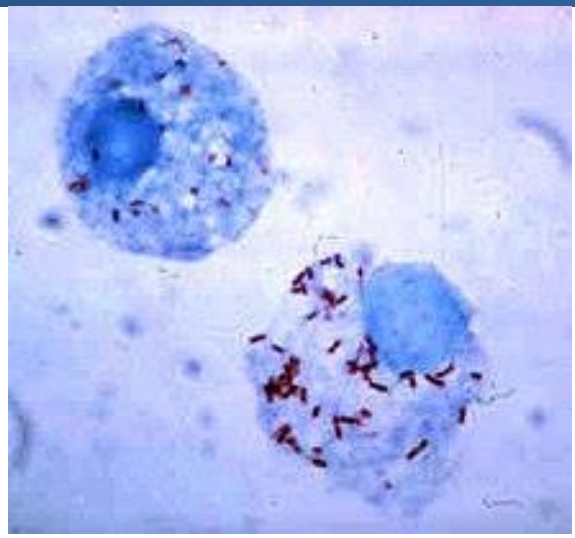
http://www.cdc.gov
Magnified rickettsiae.
TRENDS in Parasitology

Murine Typhus/Spotted Fever

- Incubation period
  - 1 to 2 weeks, commonly 12 days
- Symptoms
  - Fever and chills
  - Body aches and pain
  - Loss of appetite
  - Nausea and vomiting
  - Cough
  - Macular rash
  - Organ failure
- Treatment
  - Tetracycline group

http://www.bestonlinemd.com/typhus-fever-risk-possible-complications/

Rocky Mountain Spotted Fever



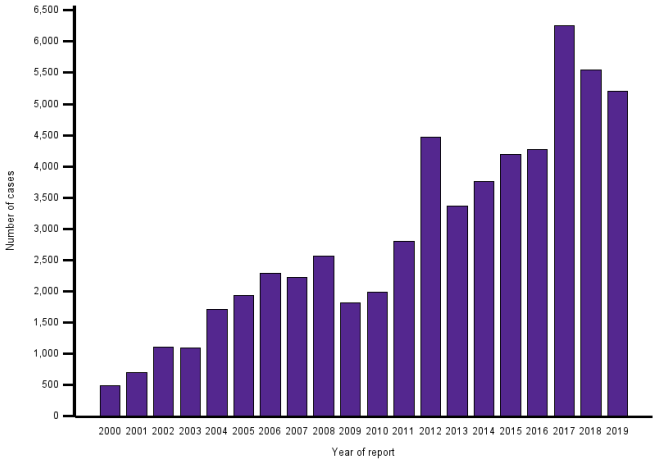
https://en.wikipedia.org/wiki/Rickettsia_rickettsii

- Agent
  - *Rickettsia rickettsii*
  - Gram negative intracellular cocci
- Reservoirs
  - Small mammals (including rodents)
  - Vectors also maintain *R. rickettsii* through tranovarial transmission (mother to offspring) and are infected for life
  - Tick STD (males can infect females during mating)
- Vector
  - *Dermacentor variabilis, Dermacentor andersoni* and *Rhipicephalus sanguineus* (mostly Mexico)
- Mode of transmission
  - From the bite of an infected tick
  - Open wound exposure to feces of an infected animal
  - Consuming food/drink contaminated with feces of an infected animal
- Incubation period
  - 3 to 14 days

Rocky Mountain Spotted Fever

- Symptoms
  - Fever
  - Headache
  - Rash (appears 2 to 4 days after fever)
  - Nausea
  - Vomiting
  - Stomach pain
  - Muscle pain
  - Lack of appetite
  - Hearing loss
  - Amputation from leaky blood vessels
  - Paralysis
  - Mental disabilities
- Treatment
  - doxycycline

Figure 1–Number of reported cases of spotted fever rickettsiosis –United States, 2000–2019



https://www.cdc.gov/rmsf/stats/index.html

https://www.cdc.gov/rmsf/symptoms/index.html

CDC Complete List per website

- Direct
  - Hantavirus Pulmonary Syndrome VIRUS
  - Hemorrhagic Fever with Renal Syndrome
  - Lassa Fever
  - Leptospirosis
  - Lymphatic Chorio-meningitis
  - Omsk Hemorrhagic Fever
  - Plague
  - Rat-Bite Fever
  - Salmonellosis
  - South American Arenaviruses
  - Tularemia
- Indirect
  - Babesiosis
  - Colorado Tick Fever
  - Cutaneous Leishmaniasis
  - Human Granulocyctic Anaplasmosis
  - La Crosse Encephalitis
  - Lyme Disease
  - Murine Typhus
  - Omsk Hemorrhagic Fever
  - Powassan Virus
  - Scrub Typhus
  - Ricketssialpox
  - Relapsing Fever
  - Rocky Mountain Spotted Fever
  - Sylvatic Typhus
  - West Nile Virus

DSHS may accept some samples

- Animals in suspected rabies cases
- Tick samples found attached to a person
  - Available to Texas residents
  - Not disease diagnosis
  - https://www.dshs.texas.gov/IDCU/health/zoonosis/animal/bites/Ticks/Tick-Submission-and-Testing.aspx
  - Fill out form
- Triatomine (kissing bug) found in someone's home
  - Available to Texas residents
  - Not a disease diagnosis
  - https://www.dshs.texas.gov/idcu/health/zoonosis/Triatominae/
- Triatomine (kissing bug) found not in someone's home nor were they suspected in biting someone may be accepted by TAMU
  - http://kissingbug.tamu.edu/Contact

One last thought…

- If both of these are not a “pet”; which pest should you treat first? The flea, or the rat?

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